Multialkali Photocathodes Effort at Argonne – Goal and Approach

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Global Ultimate Goal

- 8 inch × 8 inch photocathode
- High and uniform quantum efficiency
- Long lifetime
- Low dark current
- “Easy” integration with photodetector assembly

Ossy Sigmund/ SSL leads the effort for bialkali photocathode studies. The parallel effort here at Argonne will compliment this effort by studying not only basic physics of the bialkali/multialkali photocathodes, but also integration/assembly issues and a possibly a simpler/cheaper(?) alternative to photocathode fabrication.

The Approach

The approach to achieving the goals can be roughly divided into two areas:

1. **The study of the basic physics of the material and how it affects the desired properties**. This involves two major efforts: (i) the fabrication of the photocathode, preferably single-crystal materials, and (ii) the study of material characteristics using various diagnostics (eg: STM, XRD, Auger, etc.);
2. **The investigation on how to integrate the photocathode into the photodetector assembly**. This investigation studies how the photocathode fit into the assembly. This includes the study of suitable conducting layer, suitable substrate/window material, how the photocathode's characteristics changes in inert gas environment, how to fabricate an 8"x8" photocathode, etc.

While the effort has been divided into two areas, they are not separated from each other. It is expected that one may influence each other, or dictate the line of investigation of the other.
In addition, the characterization station is expected to be a shared resource with the advanced photocathode effort (GaAs, nanostructure, etc.).

1. The Approach to Study Basic Physics of Bialkali/ Multiakali Photocathodes

- Photocathode fabrication. Not many single-crystals have been studied, if any. Necessary if fundamental basic physics properties is needed. Propose to synthesize these photocathodes using molecular beam epitaxy (MBE) (see Kathy's presentation for the proposed fabrication chamber;
- Primary focus will be on RbCsSb and KCsSb systems;
- Characterization station. Several diagnostic systems that will reveal various physical characteristics of the photocathode. (i) LEED/RHEED: crystal orientation/ structure; (ii) XPS/Auger: band structure; (iii) STM: surface morphology and energy band structure at and near the Fermi level.
- Design and construction of vacuum transfer system between fabrication chamber and characterization station. This could be transfer between connected vacuum chamber, or a transfer to a system at a completely different location. This is predominantly an engineering design issue.

Question to be addressed: Can we understand the various material properties that are responsible for the various physical characteristics of the photocathode? Can these be tailored to our needs?

2. Integration of Photocathode With the Photodetector Assembly

- "Standard" photocathode fabrication. Can this be scaled up to 8" x 8"? If we can make good photocathode on a small scale, we have plans on how to scale this up to 8" x 8".
- Study window/substrate material, and possible conductive layer in between the window and photocathode. How does the layer changes the properties of the photocathode? How thick should the conductive layer and photocathode be? What is the appropriate resistivity of the conductive layer?
- Can a photocathode survive in an inert gas environment? Testing of various photocathode properties such as QE and lifetime inside an inert gas environment. The ability to store photocathodes in such inert gas environment can highly simplify the photodetector assembly.

Questions to be addressed: Can we make an 8" x 8" photocathode with sufficiently "good" properties? Can it be done on quartz? Can this be kept in a less demanding environment other than high vacuum?

Deliverables for First Year of Effort

- Design of MBE chamber/Begin to acquire hardware and assembly
- Design and build a vapor deposition chamber to make small samples of RbCsSb and/or KCsSb
- Design of vacuum transfer system/Begin to acquire hardware and assembly
- Design/Decision on characterization station/s

Issues to be Decided

- Location of photocathode fabrication chamber/the “ownership” of the fabrication chamber
- Location and ownership of characterization station/s. Will it be a multiple station at various locations at Argonne?
- Human resources – Is this sufficiently staffed by postdocs/graduate students, or will it also require a FTE?
- Worthwhile doing basic physics?

Broad Dichotomy of Proposed Photocathode Work